

DØ Experiment and BNL

presented by

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(for the DØ BNL Group)

Department of Energy Review

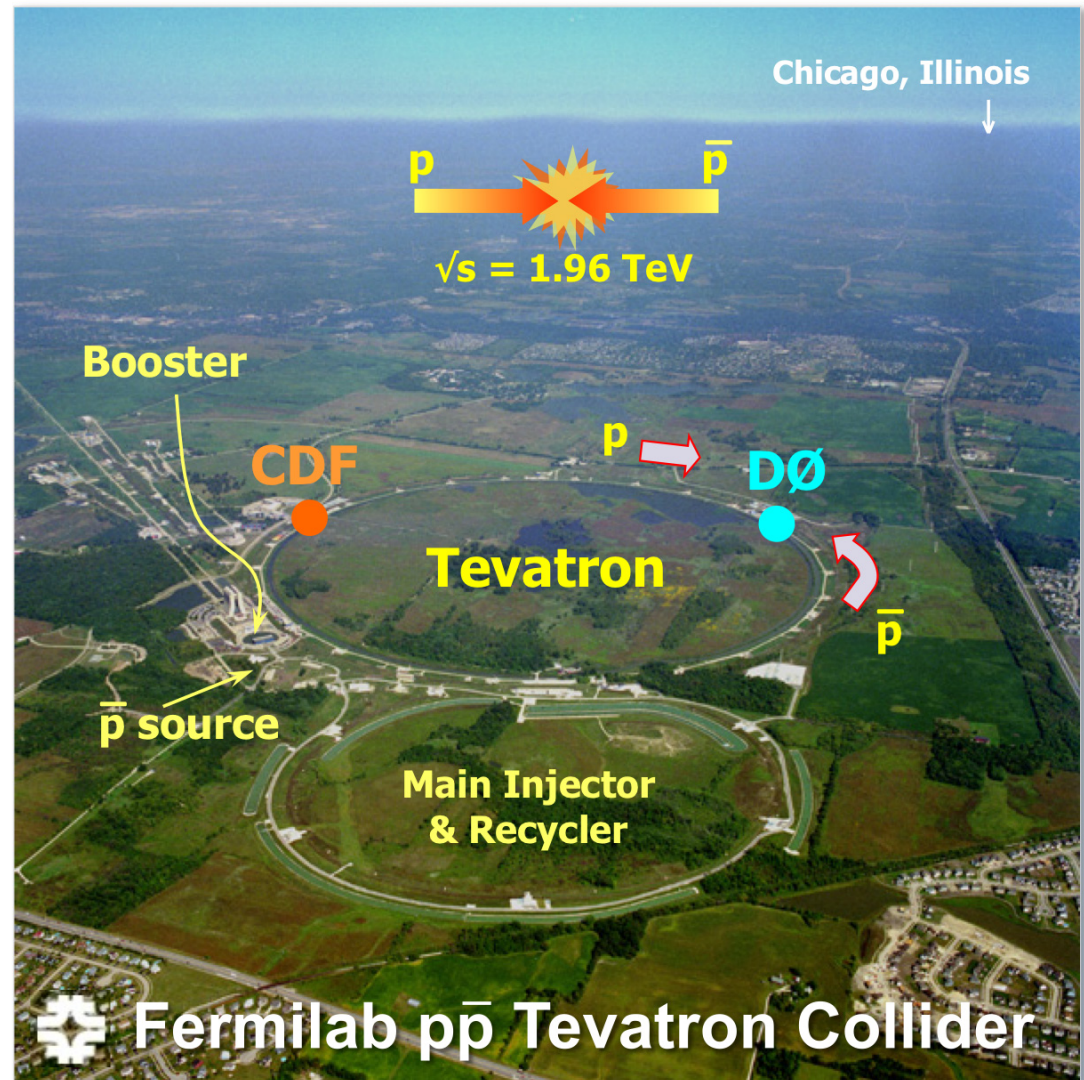
May 19-21, 2010

BROOKHAVEN
NATIONAL LABORATORY

a passion for discovery

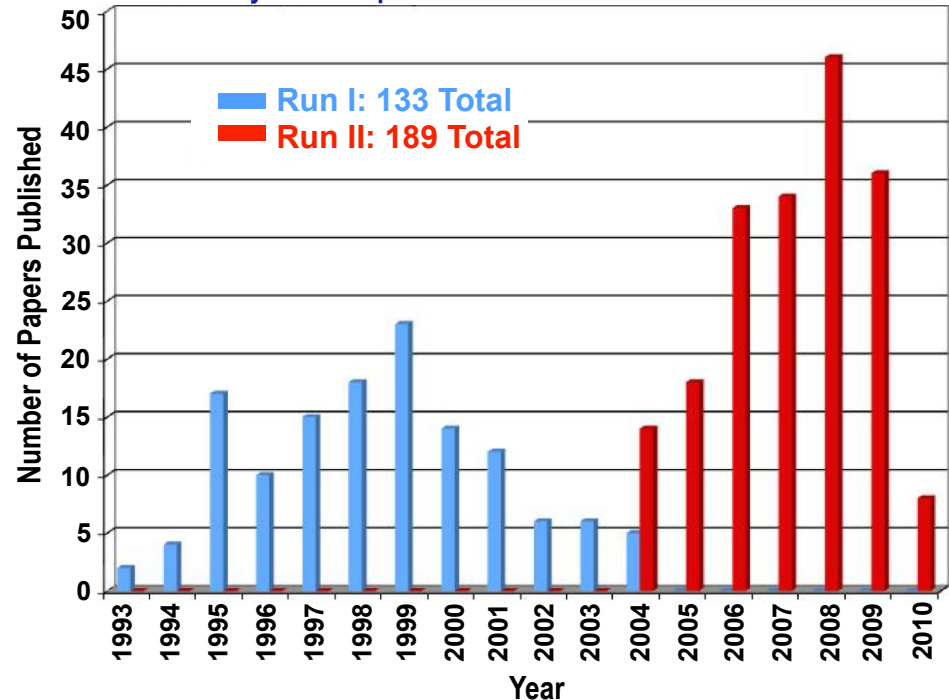


- ❖ **Overview of Results from DØ Experiment**
- ❖ **BNL-DØ Personnel**
- ❖ **Major BNL Contributions**
- ❖ **Present Status and Physics Results**
- ❖ **Closing Summary and Future Plans**





History of DØ Papers Published in Peer-Reviewed Journals



❖ Run II (2004-present) publications

- 189 publications accepted, additional 10 submitted

❖ On average, new paper submitted ~ every week during 2008-2010

- results across all physics areas
- past year, BNL-DØ group co-authored or reviewed 13 papers

❖ DØ Preliminary or Published Results presented at major conferences — with BNL involvement, in FY09 & FY10

- “Search for the SM Higgs boson in $\tau\tau q\bar{q}$ final state” 4.9 fb^{-1}
- “Search for SM Higgs in $WH \rightarrow \tau\nu b\bar{b}$ channel” 4.0 fb^{-1}
- ★ ▪ “Combined upper limits on MSSM Higgs boson to $\tau\tau$ final states” $1\text{-}2.2 \text{ fb}^{-1}$
- ★ ▪ “Search for a resonance decaying into WZ boson pairs in $p\bar{p}$ collisions” 4.1 fb^{-1}
- ★ ▪ “Combination of DØ top quark mass measurements” $0.1\text{-}3.6 \text{ fb}^{-1}$
- ★ ▪ “Dependence of $t\bar{t}$ cross section on p_T of the top quark” 1.0 fb^{-1}

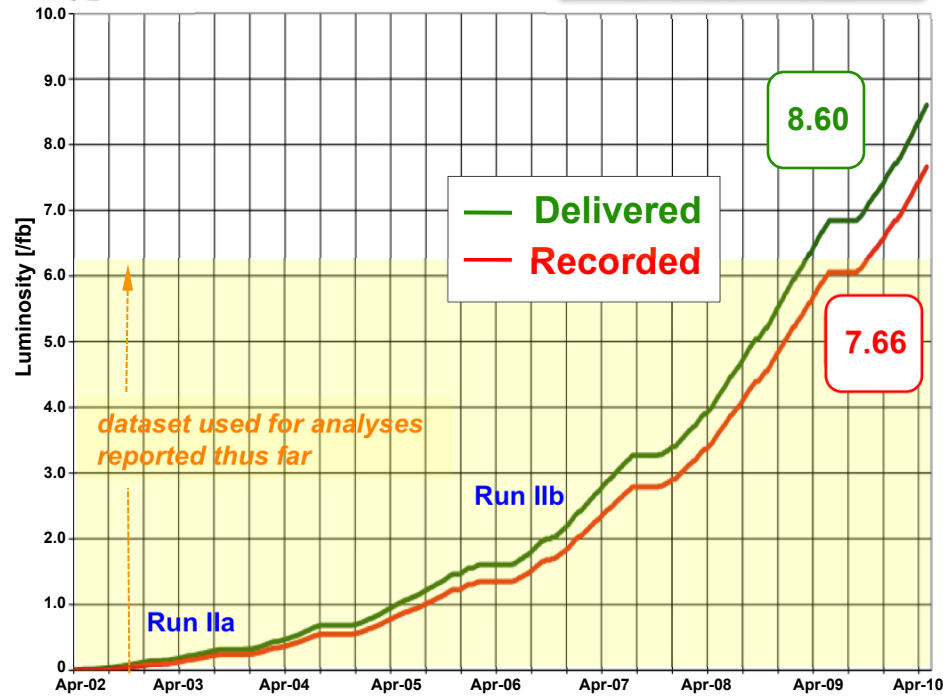


Tevatron and DØ Performance



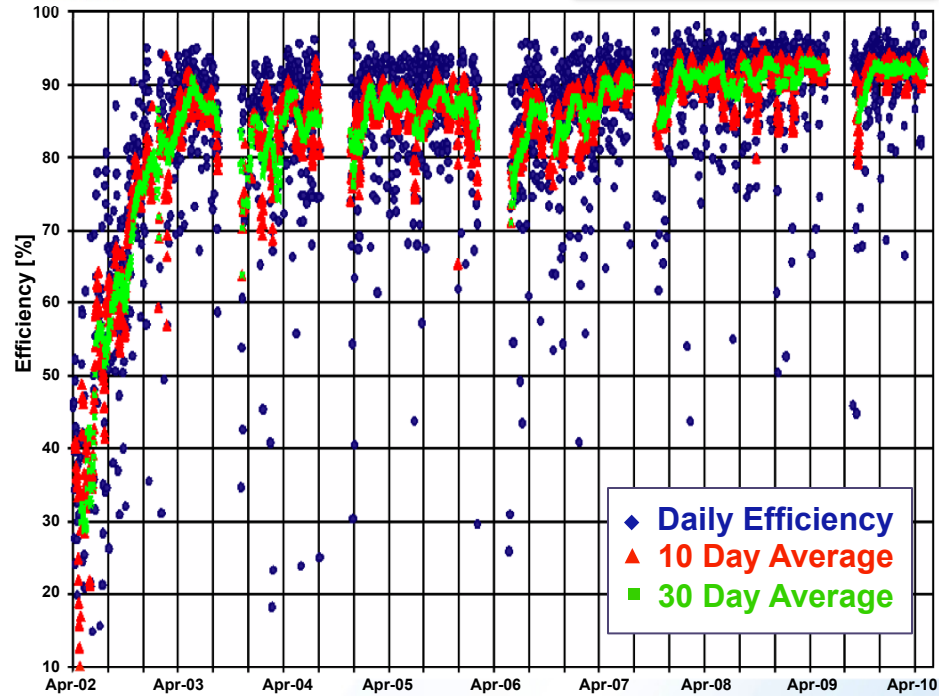
Run II Integrated Luminosity

19 April 2002 – 16 May 2010



Daily Data Taking Efficiency

19 April 2002 – 16 May 2010



❖ Tevatron Collider and DØ operating successfully in Run II

- Tevatron delivered $\int \mathcal{L} dt \rightarrow 8.60 \text{ fb}^{-1}$ of data: DØ recorded 7.66 fb^{-1}
- up to 6.1 fb^{-1} [Run IIa & Run IIb] dataset used in DØ analyses reported thus far

❖ Projections through end-FY11: expect to collect $\sim 11 \text{ fb}^{-1}$ data

❖ Stable operations at DØ with recent $\sim 92\%$ data taking efficiency

- excellent performance due to dedicated 24/7 effort from shifters & detector experts
 - BNL-DØ expert roles in Preshower and Luminosity Monitor subsystems
 - shift contributions include Captain, Tracking/Preshower, SAM database

❖ FY10 BNL-DØ members

- A. Patwa (100%), S. Snyder (10%), T. Gadfort (10%), M. Begel (10%), M-A. Pleier (10%), S. Protopopescu (10%), K.Yip (20%, not in core program)
 - 1.5 FTE in core program (1.7 FTE total)
 - continue transition to ATLAS while maintaining needed role on DØ
- A. Evdokimov: BNL guest appointment
 - DØ effort shared between FNAL (25%) and BNL (25%)
 - resident at Fermilab

❖ Past Year Service Contributions

- Central and Forward Preshowers (CPS, FPS) hardware and software maintenance — A. Evdokimov: CPS and FPS, A. Patwa: FPS
- τ -ID Algorithm Group Co-convenor — A. Patwa
- Online and Offline Software support — S. Snyder
- Shift responsibilities —
 - a) A. Patwa & S. Snyder (*Captains*)
 - b) A. Evdokimov (*Central Tracker and Preshowers*)
 - c) M-A. Pleier, S. Protopopescu, and K.Yip (*Remote SAM database*)

❖ Physics

- Search for MSSM Higgs Boson in $h \rightarrow \tau\tau$ channel
 - A. Patwa
 - * presently: Beyond Standard Model (BSM) Higgs group convener
 - oversee searches across $bh \rightarrow b\bar{b}\bar{b}$, $h \rightarrow \tau\tau$, $bh \rightarrow b\tau\tau$, $VH \rightarrow qq\bar{b}\bar{b}$, $ZH \rightarrow \tau\tau jj$, $WH \rightarrow \tau\nu b\bar{b}$, $H \rightarrow WW \rightarrow \tau\nu\tau\nu$, and NMSSM channels
- QCD and Top Cross Section Measurements
 - M. Begel
- Search for New Phenomena: W' and Lepto- and Vector-quark Production
 - T. Gadfort

❖ Membership in Physics Editorial Boards

- Top Mass
 - S. Protopopescu^(†), M. Pleier⁽⁺⁺⁾, S. Snyder, and A. Patwa
- Top Pair Production in Dilepton and All-jet Channels
 - T. Gadfort⁽⁺⁺⁺⁾
- Inclusive Jet and High- p_T Jet Production
 - M. Begel^(†)
- New Phenomena & Low-Mass SM Higgs Searches with Heavy-flavor Jets
 - A. Patwa

^(†)EB Chair til August 2008; still member

⁽⁺⁺⁾Joined BNL staff August 2009

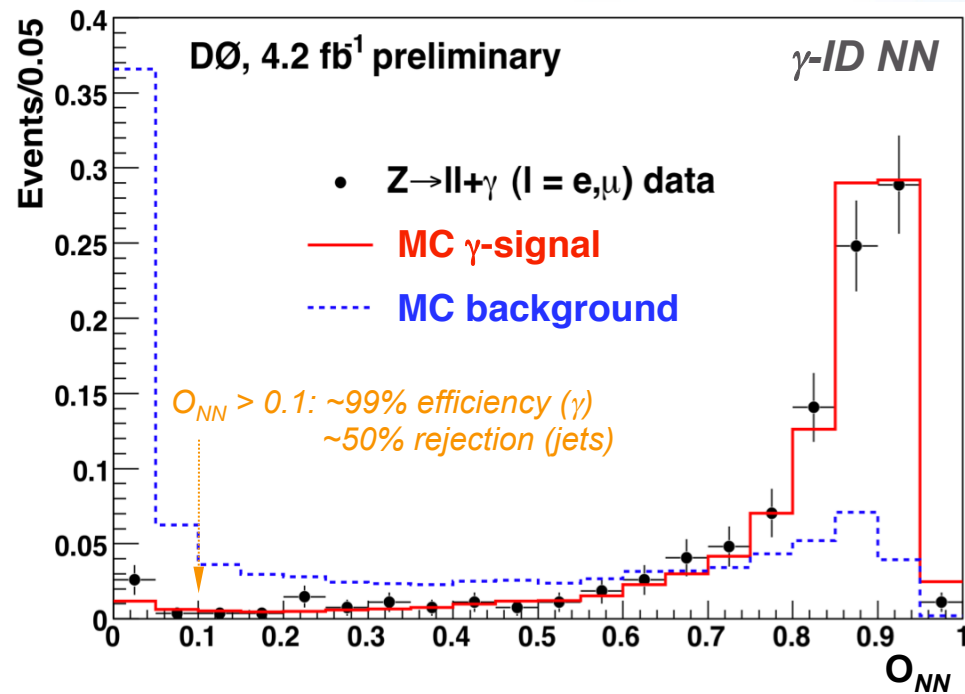
⁽⁺⁺⁺⁾Goldhaber Distinguished Fellow since October 2009

❖ Effort on improving performance of preshowers and inclusion into event selections for physics analyses

- e.g., implement energy-weighted width of CPS in Neural Net (O_{NN}) for e- or γ -ID
 - exploit fact that preshower width narrower for photons than for jets
 - addition of CPS: achieve $\sim 15\%$ improvement in S/B for direct- γ production at high- p_T
- analyses with CPS selections include
 - $H \rightarrow \gamma\gamma$, SUSY di-photon searches, QCD γ + jet measurements...

❖ FPS

- past year, completed calibration with Run IIb upgraded AFE-II boards, which restored full dynamic range
- future plans coordinated by A. Evdokimov include
 - development of e/ γ -ID in End-Calorimeter region using FPS
 - improvement of EM resolution at forward rapidities
 - similar inclusion into physics analyses



❖ Published $Z \rightarrow \tau\tau$ cross section

- PRD 71, 072004 (2005): 226 pb^{-1}
 - benchmark study for testing and certifying τ -ID algorithm based on NN
- PLB 670, 292 (2009): 1.0 fb^{-1}
- S. Protopopescu, A. Patwa have led τ -ID development and coordination efforts

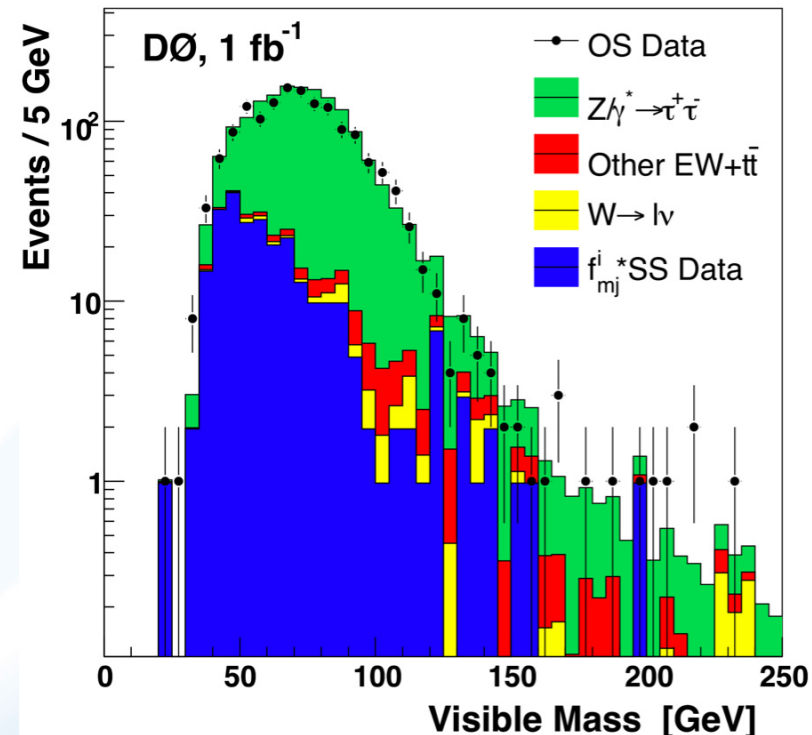
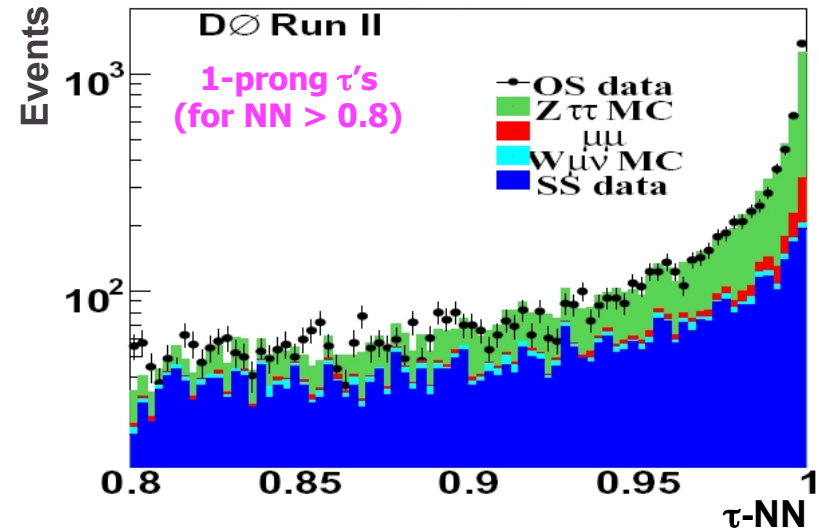
❖ $\sigma(p\bar{p} \rightarrow Z + X) \times \text{Br}(Z \rightarrow \tau^+ \tau^-)$

- PRD: $237 \pm 15 \text{ (stat)} \pm 18 \text{ (sys)} \pm 15 \text{ (lum)} \text{ pb}$
- PLB: $240 \pm 8 \text{ (stat)} \pm 12 \text{ (sys)} \pm 15 \text{ (lum)} \text{ pb}$
- SM theory (NNLO): $241.6^{+3.6}_{-3.2} \text{ pb}$

❖ Methods developed for $Z \rightarrow \tau\tau$ have been extended to other τ -based physics analyses

❖ Expertise gained with τ 's from DØ propagated to object-ID efforts in ATLAS

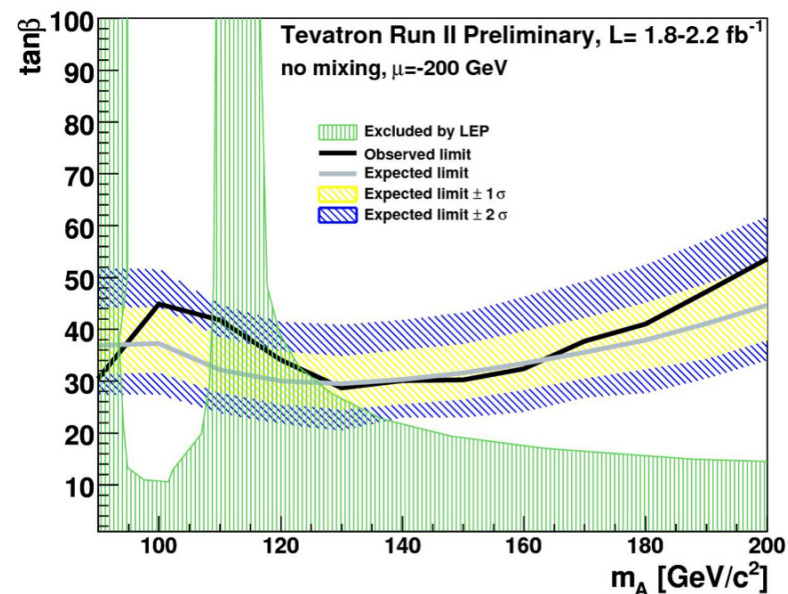
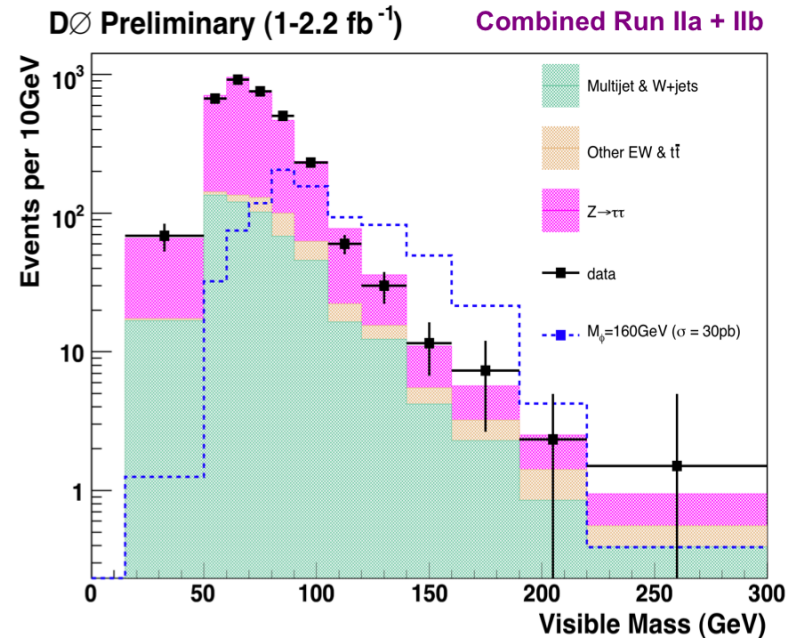
- S. Protopopescu active in ATLAS τ -ID group





MSSM Higgs: Inclusive $\tau\tau$ Search

- ❖ **Result using 1.0 fb⁻¹ dataset for $\tau_\mu\tau_h$, $\tau_e\tau_h$, and $\tau_e\tau_\mu$: PRL 101, 071804 (2008)**
- ❖ **Updated 2.2 fb⁻¹ result considers $\tau_\mu\tau_h$**
 - isolated μ separated from τ_h : opposite-sign
 - τ -ID NN discriminates hadronic τ from jets
- ❖ **No excess in data across visible mass spectrum**
 - exclusion limits in MSSM (m_A , $\tan\beta$) plane
 - Dawson, Kilgore (BNL) contributed to theory
- ❖ **New Tevatron (DØ, CDF) combination for $\tau\tau$ search channels**
 - with a fraction of final dataset, probing interesting region of $\tan\beta \sim 30$ [$\mathcal{O}(m_{top}/m_b)$]
 - most stringent limits on $\tan\beta$
- ❖ **In publication mode with 5.3 fb⁻¹ data**
 - A. Patwa to continue with Saclay group on search efforts with larger dataset
 - aim for observation or reach sensitivity of $\tan\beta \sim 20$ for low m_A



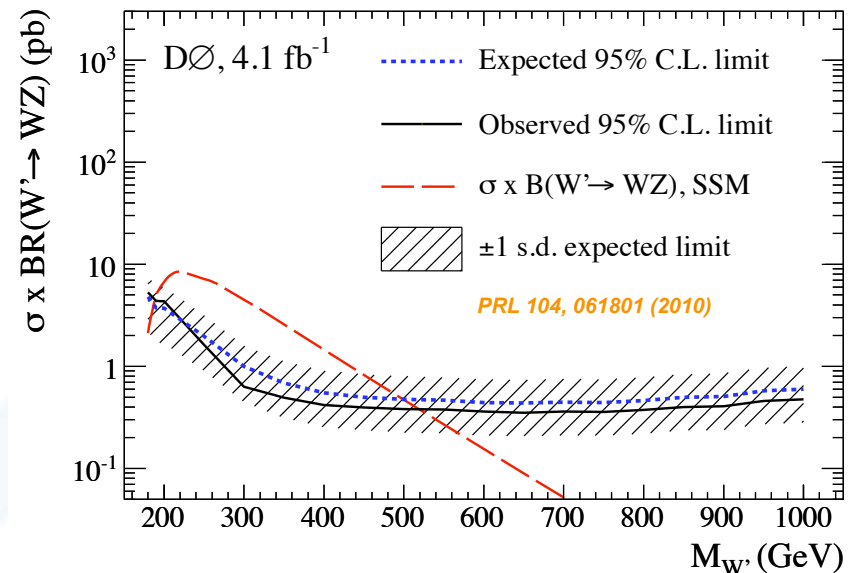
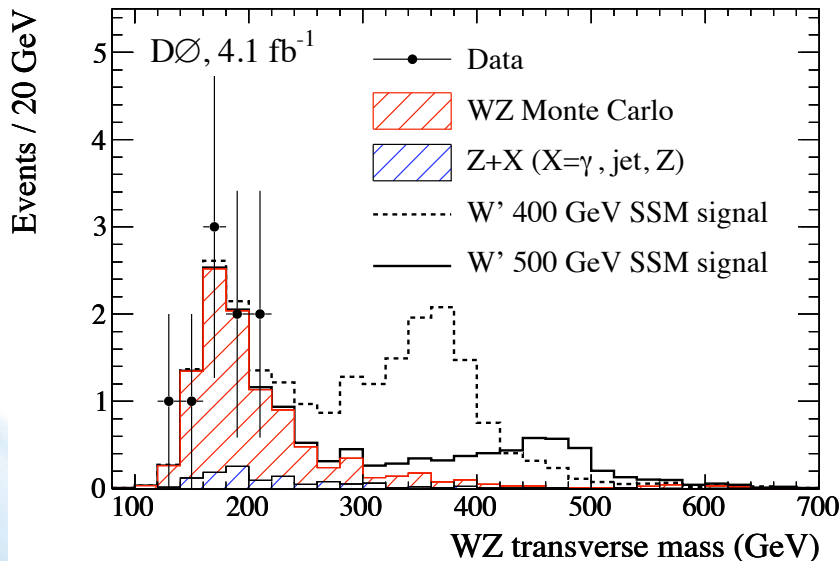
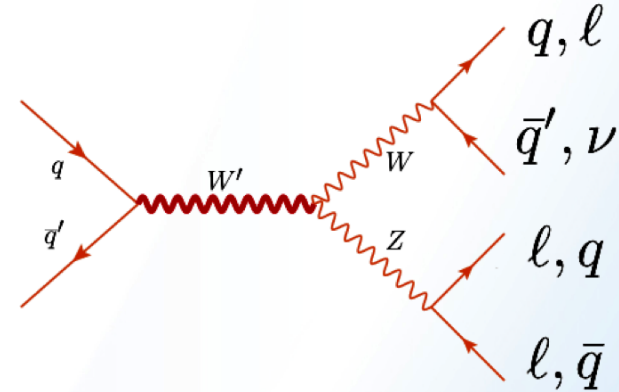


❖ T. Gadfort leading publication effort of $W' \rightarrow WZ$ search

- new addition to BNL Omega group: Goldhaber Distinguished Fellow, Oct. 2009
- $W' \rightarrow WZ \rightarrow \ell \nu \ell \ell$ 4.1 fb⁻¹ search: PRL 104, 061801 (2010)
- $W' \rightarrow WZ \rightarrow jj \ell \ell$ and $\ell \nu jj$ 5.4 fb⁻¹ analysis: in Editorial Board review
 - working in collaboration with Kansas State and Columbia U.

❖ Search for resonance in reconstructed W' transverse mass spectrum

- 9 data events consistent with predicted backgrounds
- 95% C.L. limits on $\sigma \times \text{Br}(W' \rightarrow WZ)$
 - within SSM, exclude $188 < M_{W'} < 520$ GeV
 - first limit to-date on $W' \rightarrow WZ$ production

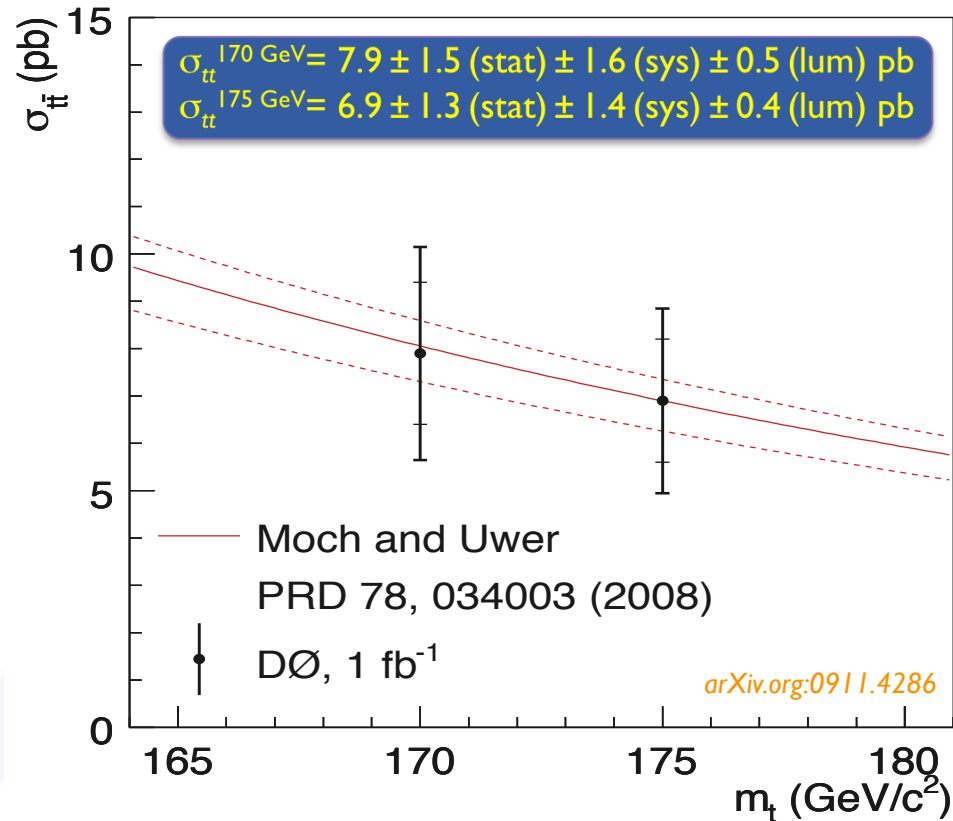
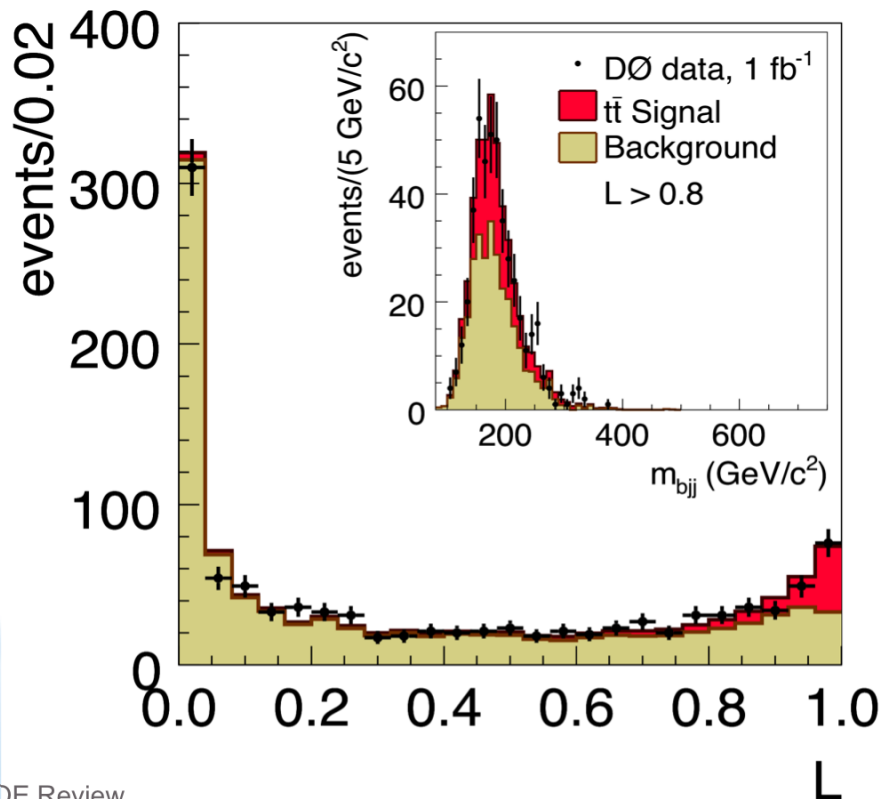
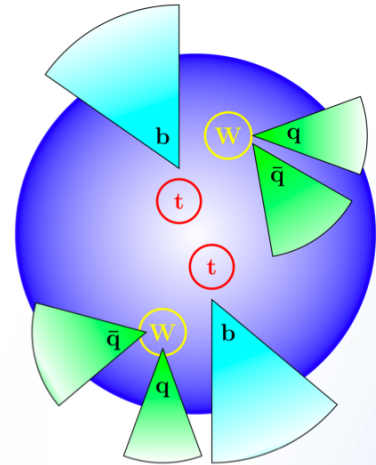


❖ $t\bar{t}$ production in all-hadronic channel

- M. Begel led effort
- 1.0 fb^{-1} publication submitted to PRD

❖ Challenging signal-to-background

- six-jet background sample taken from data (S:B of 1:1300)
- signal enhanced by requiring two b -tagged jets (S:B of 1:50)
- suppress background by requiring four high- p_T jets (S:B of 1:7)
- extract signal via topological likelihood



- ❖ **Measurements of differential cross section in $t\bar{t}$ system**
 - important test of pQCD for heavy quark production
 - can constrain potential physics beyond standard model

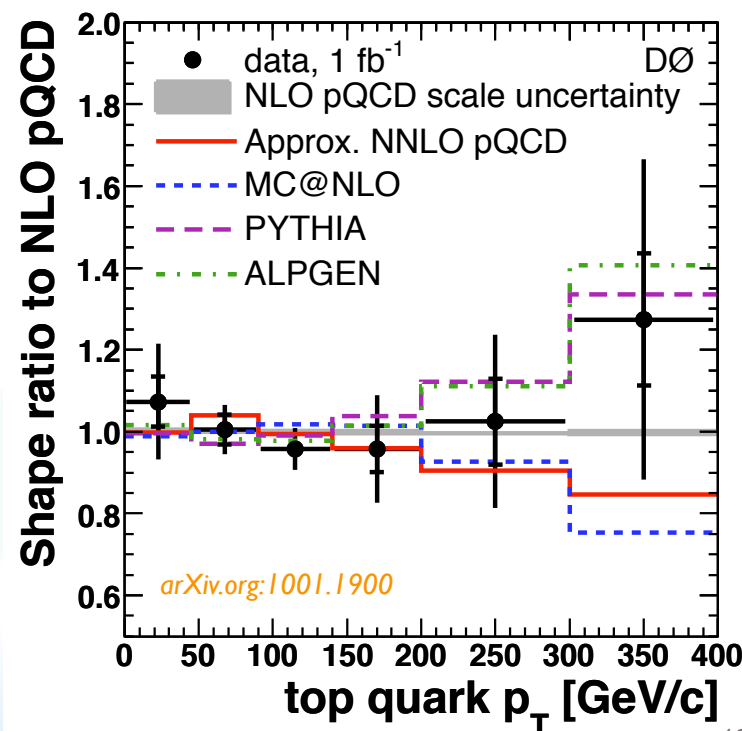
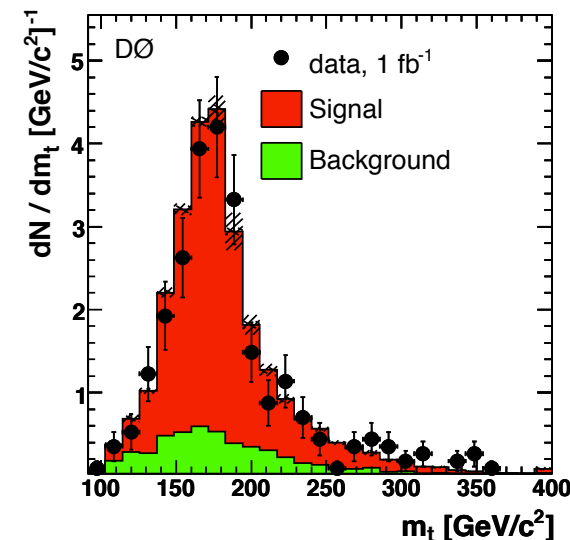
- ❖ **1.0 fb⁻¹ publication led by M. Begel: submitted to PLB in Jan. 2010**

- data sample and selections based on inclusive $t\bar{t} \rightarrow \ell + \text{jets}$ cross section measurement
- uses constrained kinematic fit developed by S. Snyder to assign ℓ and jets with $t\bar{t}$ -pairs

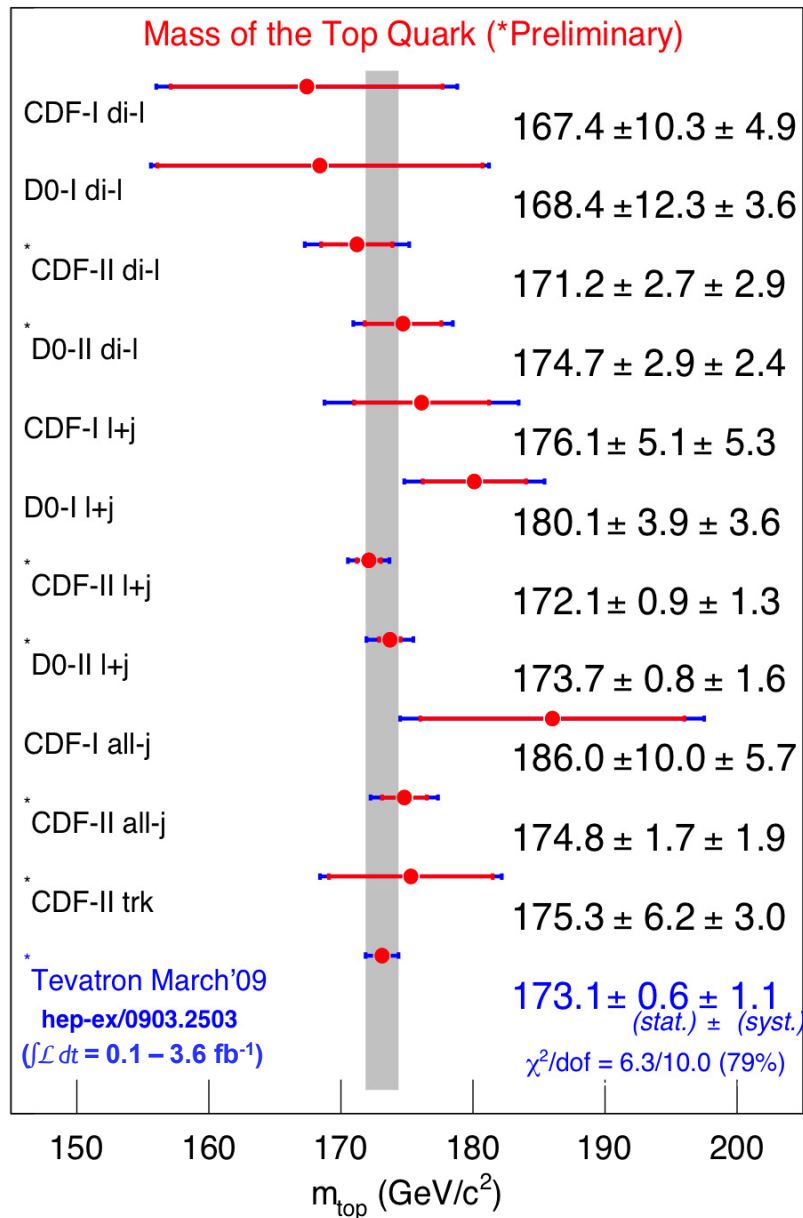
- ❖ **compare shape of measured differential cross section ($1/\sigma d\sigma/dp_T$) with expectation from NLO pQCD**

- also compare with approximate NNLO pQCD calculation and several event generator
- Dawson (BNL) contributed to NLO pQCD

- ❖ **all calculations currently reproduce the measured shape in data**



arXiv.org:1001.1900



❖ Editorial Board

- strong contribution from BNL physicists in reviewing precision measurements of top mass at DØ

❖ S. Protopopescu, S. Snyder, and M-A. Pleier also focusing on top physics at ATLAS

❖ Measurements of m_{top} from different decay channels and using different methods yield consistent results

❖ Single experiment's top quark mass precision reaching 1 GeV

- efforts on reducing systematic uncertainties

❖ New results expected this Summer... for ICHEP 2010

$$m_{\text{top}}(\text{Tevatron}) = 173.1 \pm 0.6 (\text{stat}) \pm 1.1 (\text{syst}) \text{ GeV}$$



- ❖ **Tevatron and DØ detector performing well**
 - expect ~ 10 (12) fb^{-1} of Tevatron delivered data by end-FY10 (FY11)
- ❖ **BNL service contributions and expertise in**
 - preshower detector maintenance and object identification
 - τ -ID algorithm and reconstruction
 - software and infrastructure support
- ❖ **Strong focus on Higgs, W' , and top physics analyses at DØ**
 - convening BSM Higgs physics group
 - search for MSSM Higgs in $\tau\tau$ final states
 - leading publication effort of W' search
 - top quark cross section and mass measurements

BNL collaborators continue to be well-situated to apply the expertise gained from DØ in areas including hardware, software, and physics analysis to our efforts on ATLAS

❖ Maintaining expertise on DØ while transition to ATLAS continues...

FY11 plan for DØ effort includes

- complete publication of MSSM Higgs search with 5.3 fb^{-1} data
 - provide support for 7-9 fb^{-1} MSSM $h \rightarrow \tau\tau$ search
- continue necessary expert-level roles and software support for DØ operations
- membership in Editorial Boards
 - Top mass
 - NP and low-mass SM Higgs to HF jets

Fiscal Year	FTE on DØ (core program)
2007	2.7
2008	2.0
2009	1.5
2010	1.5
2011	0.7
2012 (?)	0.3

❖ Projected FY11 BNL-DØ members

- A. Patwa (60%), S. Snyder (10%), T. Gadfort (0%), M. Begel (0%), M-A. Pleier (0%), S. Protopopescu (0%), K.Yip (20%, not in core program)
 - 0.7 FTE in core program (0.9 FTE total)
 - core program primarily aimed to focus on analyzing ATLAS data while completing analysis and providing needed commitments on DØ
- A. Evdokimov: BNL guest appointment
 - BNL support (25%; same level as FY10) on CPS/FPS maintenance and its object-ID

❖ If FY12 Tevatron run

- 0.3 FTE (Patwa, Snyder) in core program driven by BSM Higgs searches and software support for DØ operations

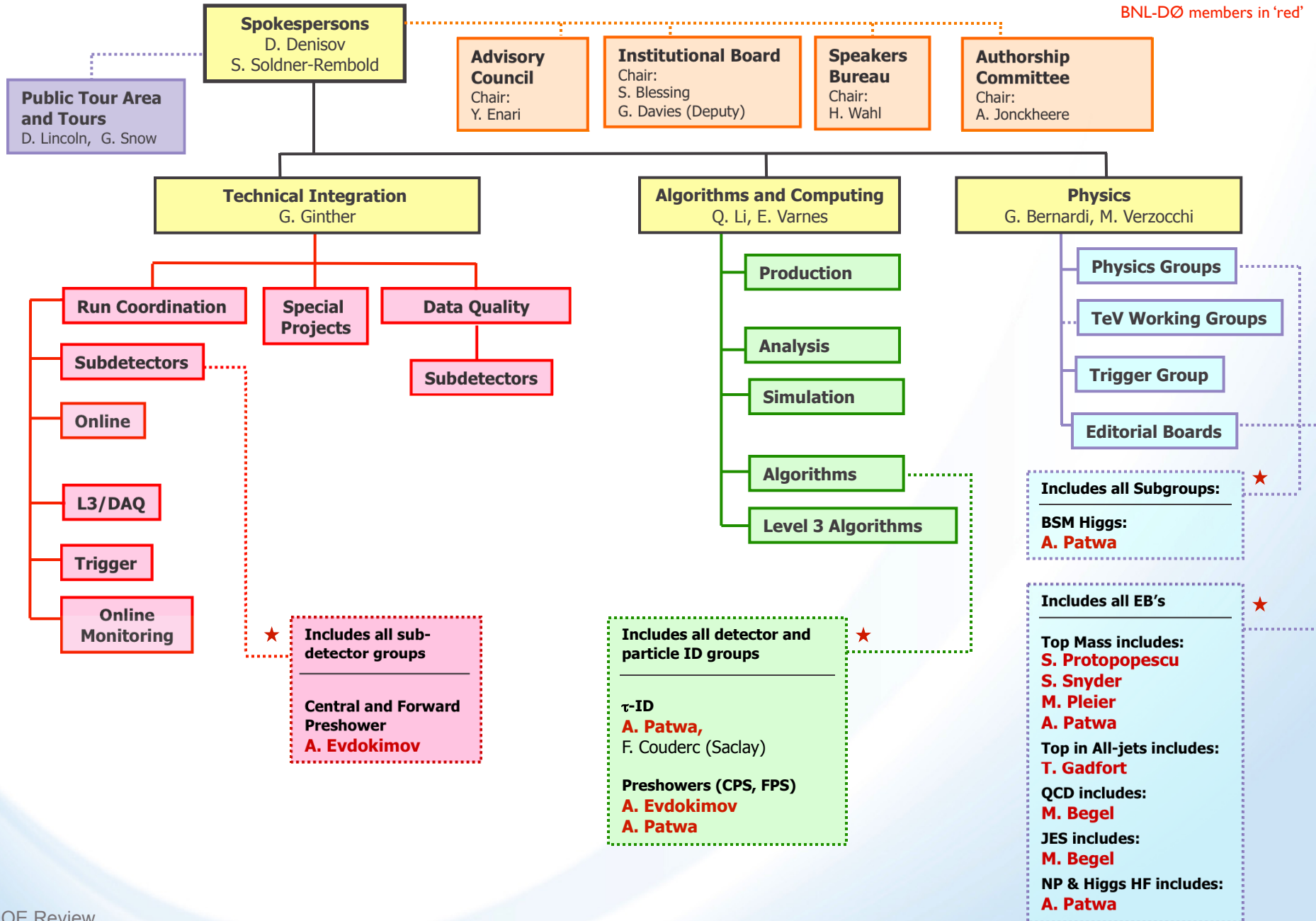


Reference Slides



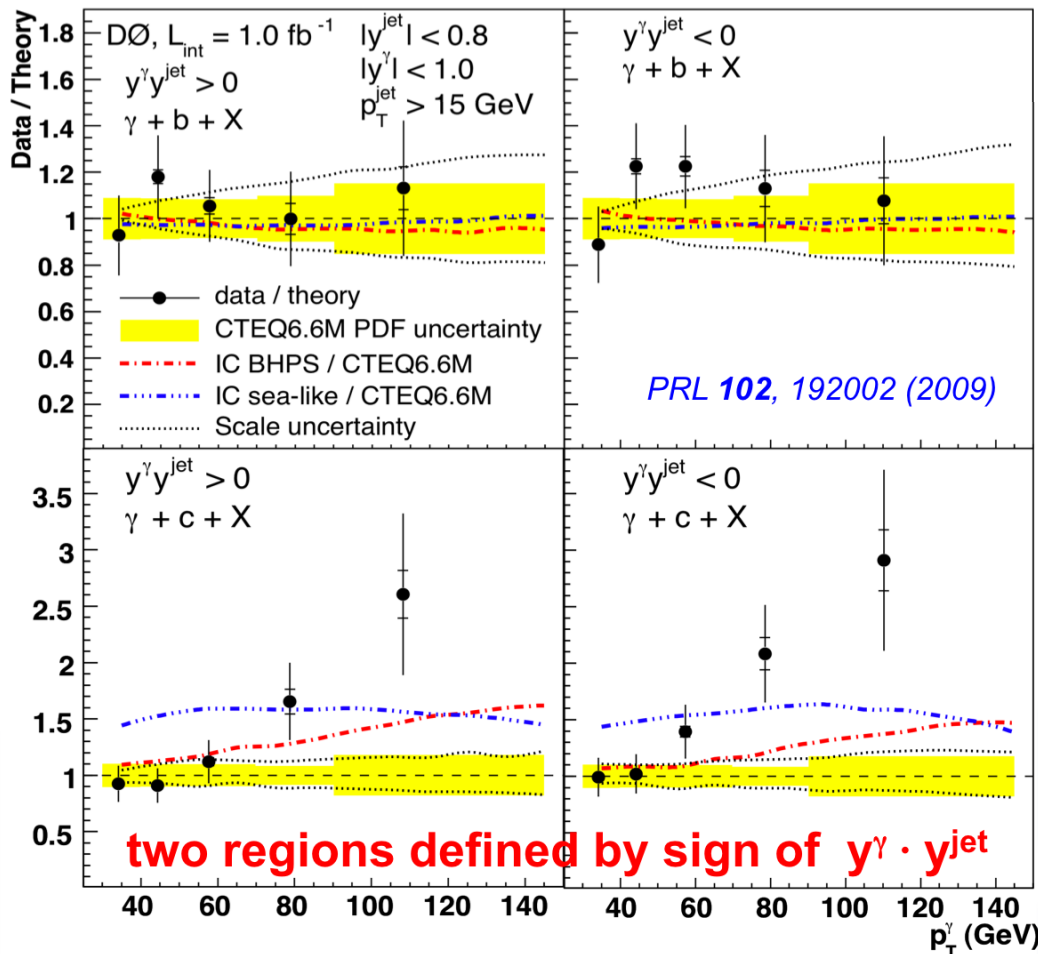
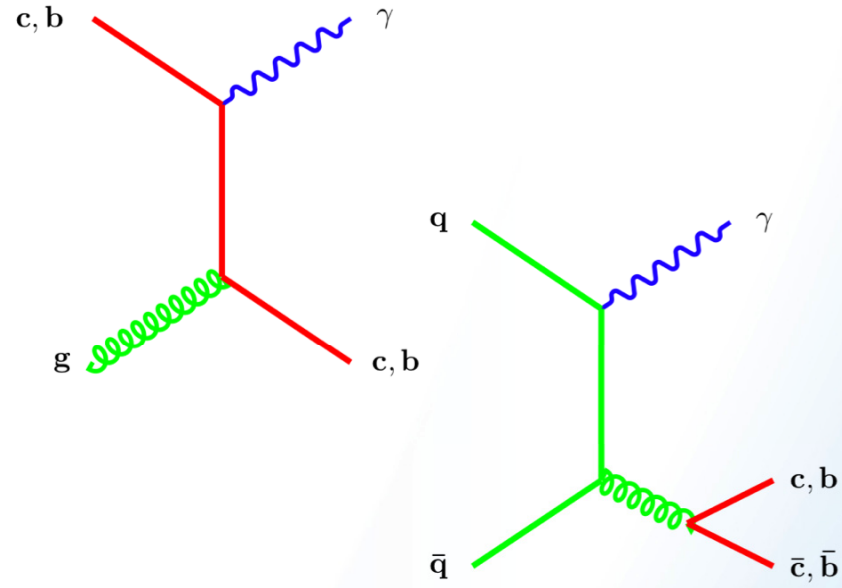
DØ Organization and BNL

BNL-DØ members in 'red'





- ❖ Heavy-flavor content of proton can be probed in $\gamma + \text{jet}$ events where the jets are flavor tagged
- ❖ **M. Begel** initiated analysis
 - based upon earlier inclusive photon and $\gamma + \text{jet}$ measurements



- ❖ **NLO perturbative QCD (pQCD) agrees with $\gamma + b$ jet measurements, but $\gamma + c$ jet data exceeds expectations at high p_T**
- ❖ **Published 1.0 fb⁻¹ result**
 - PRL 102, 192002 (2009)
 - expect to shed more light on $\gamma + c$ p_T distribution with full dataset



❖ Focus on leptonic final states and scan for significant deviations from SM

- S. Protopopescu a primary contributor & expert to MIS for new physics
- strategy based on dividing data into 7 non-overlapping, inclusive final states
 - defined according to high- p_T objects: $e, \mu, \tau, \gamma, \text{jets}, b\text{-jet}, \cancel{E}_T$
- check ‘shape’ and ‘number of events’
 - use KS-probabilities
 - normalization from fits to basic histograms:
 $p_T, \eta, \phi, \cancel{E}_T, M(\text{all combinations}), \Delta R$

❖ Final states are input to two algorithms

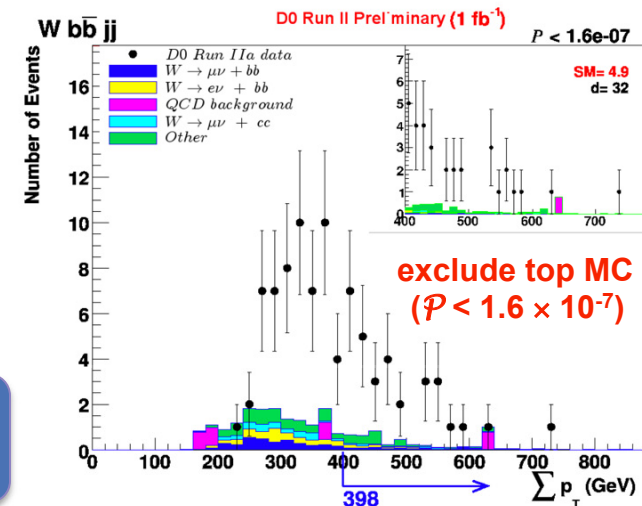
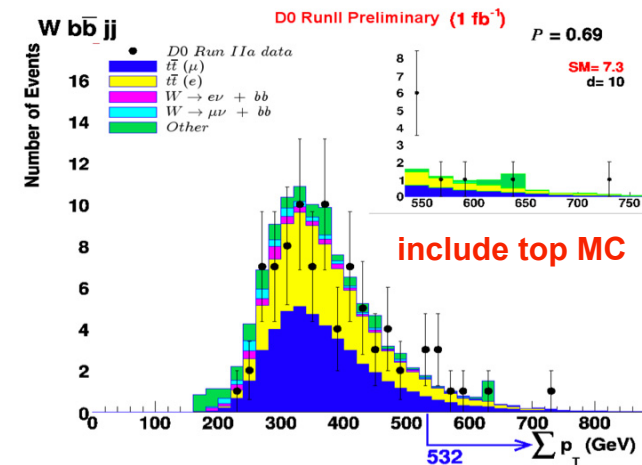
- VISTA: cycle through histograms for exclusive final states to check data vs. SM backgrounds
- Sleuth: search for excess in tails of Σp_T
 - test validity of “method” by sensitivity tests
 - e.g., with and without $t\bar{t}$ -pairs \Rightarrow “rediscover” top

❖ Results with 1 fb⁻¹

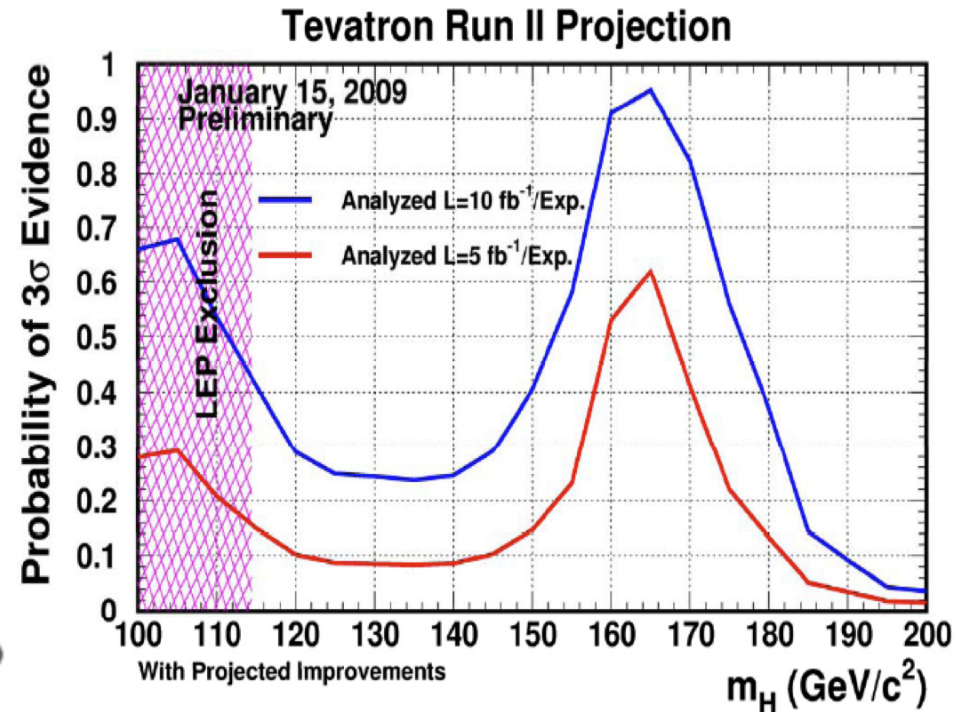
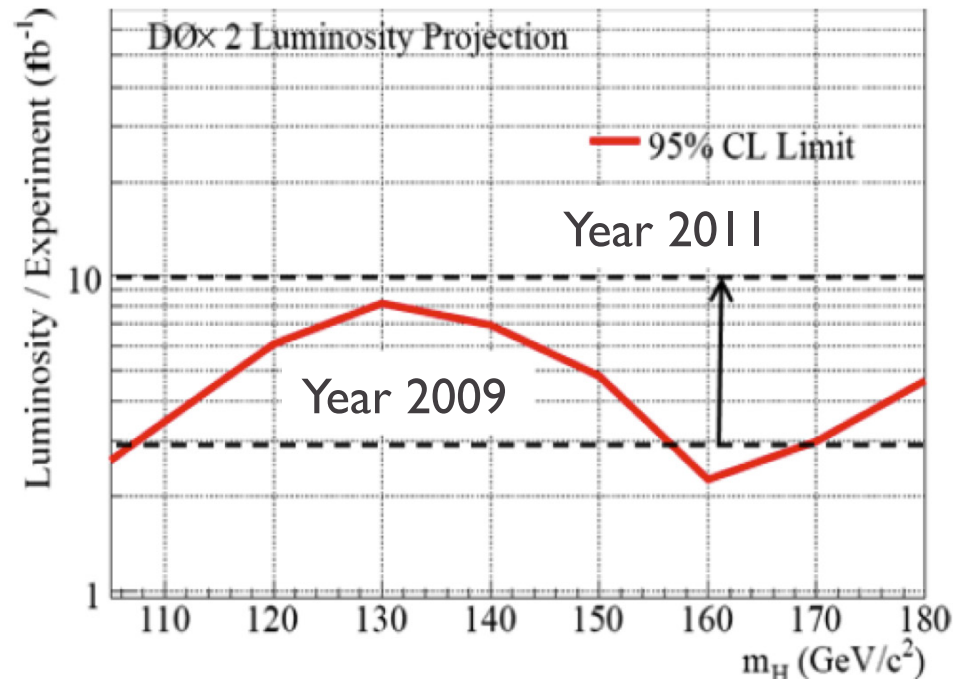
- VISTA: 4 out of 180 exclusive final states yield statistically significant ($\sim 3\sigma$) discrepancy
 - all point to known modeling difficulties
- Sleuth: one discrepancy related to μ resolution model

No hints yet... expect increased sensitivity from modeling improvements and $> \times 6$ collected data

$t\bar{t}$ -Sensitivity Test (Sleuth):



assume CDF + DØ, and analysis improvements underway



Tevatron Expected Higgs Sensitivity:
 ≥ 2011 – direct exclusion from
 115 to 185 GeV; or 1st evidence?

Probability of 3σ evidence in 2011:
 $> 40\%$ probability for
 $m_H = 115 \text{ GeV}$ with $L = 10 \text{ fb}^{-1}$